U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
City of Memphis, Memphis Light, Gas and Water Division

Scientific Investigations Map 3415

Introduction

The Memphis and Fort Pillow aquifers are the principal sources of water for municipal, industrial, and commercial uses in the Memphis area. About 207 million gallons per day (Mgal/d) of groundwater were withdrawn in Shelby County, Tennessee, from both aquifers in 2010 for these uses (Maupin and others, 2014), with most of the water coming from the Memphis aquifer. The U.S. Geological Survey (USGS), in cooperation with the City of Memphis, Memphis Light, Gas and Water Division, collects groundwater-level data in the Memphis area and periodically prepares potentiometric-surface maps for the Memphis aquifer to assess conditions in this regionally important water supply aquifer. This report presents the altitudes of the potentiometric surface of water in wells screened in the Memphis aquifer based on water-level measurements made in the fall of 2000, 2005, 2010, and 2015 and describes historical water-level changes in the Memphis aquifer at key observation wells in the Memphis area. The Memphis area is about 1,500 square miles (mi^2) and includes all of Shelby County and parts of Tipton and Fayette Counties in Tennessee, parts of DeSoto and Marshall Counties in Mississippi, and part of Crittenden County in Arkansas (fig. 1).

Memphis Aquifer

Kingsbury and Parks (1993) described the geology of the study area. The Memphis area lies within the Mississippi embayment, a broad structural syncline that plunges southward with its axis roughly coincident with the Mississippi River. The embayment contains several thousand feet of unconsolidated Cretaceous and Tertiary sediments that dip gently westward and thicken in the down-dip direction. The Tertiary-age (middle Eocene) Memphis Sand is a thick layer of sand with lenses of clay and silt and minor amounts of lignite present at various stratigraphic horizons. The Memphis Sand is present in the subsurface throughout the Memphis area and ranges from about 650 to 900 feet (ft) in thickness.

The Memphis Sand constitutes the Memphis aquifer. Confining clay beds above and below the aquifer create artesian conditions within the aquifer in much of the Memphis area; however, several studies have identified areas where the overlying Jackson-upper Claiborne confining unit is thin or absent (Graham and Parks, 1986; Parks, 1990; Bradley, 1991; Parks and others, 1995). Recharge to the Memphis aquifer from infiltration of rainfall occurs primarily east of the eastern limit of the Jackson-upper Claiborne confining unit (fig. 1), but some recharge occurs locally where the confining unit is thin or absent.

Potentiometric-Surface Maps

Four potentiometric-surface maps for the Memphis aquifer (figs. 1–4) were prepared using water-level measurements made in about 60 wells during the fall of 2000, 2005, 2010, and 2015 in the Memphis area (table 1). Generally, the same wells or nearby, alternate wells are measured as part of this water-level network. Access to some of the wells was not possible every year, however, and over time some of the network wells have been abandoned and filled, resulting in some areas not having water-level measurements. Most of the measurements were made each year within about a 4-week period between late September to early November (table 1) when water levels usually are near their lowest for the year. Therefore, the potentiometric-surface maps represent low water-level conditions in the aquifer for these years. The water-level data used as control points are available through the USGS National Water Information System web interface (USGS, 2017a).

Prior to the onset of groundwater withdrawals from the Memphis aquifer in 1886, the potentiometric surface is interpreted to have been a smooth surface with a gentle downward slope to the west-northwest (Criner and Parks, 1976). Long-term water withdrawals from the aquifer since 1886 have created a large cone of depression in the potentiometric surface, and several smaller cones of depression exist within the cone at municipal well fields in the Memphis area (figs. 1–4). The general direction of groundwater flow in the Memphis area is toward the center of the cone of depression in the Memphis aquifer located near the Mallory well field.

The shapes of the potentiometric surfaces from 2000 to 2015 are similar, but the altitude of water levels has changed in some parts of the Memphis area. Water levels have risen almost 30 ft from 2000 to 2015 in the center of the cone of the depression (figs. 1 and 4). Locally, in 2015, water levels were 20 ft higher at the Mallory, Morton, and Sheahan well fields and about 30 ft higher at the Allen well field than they were in 2000. Groundwater levels east of the McCord and Lichterman well fields have not shown consistent increasing or decreasing trends from 2000 to 2015.

Historical Water-Level Changes

Hydrographs for selected wells show the varying degree to which long-term withdrawals from the Memphis aquifer have affected water levels in the Memphis area (fig. 5). Water levels measured in wells within the large cone of depression in the potentiometric surface have declined substantially compared to those in wells in outlying areas, where smaller water-level declines have occurred. Because of the confined conditions of the Memphis aquifer throughout much of the Memphis area, the seasonal fluctuation in water levels recorded in these observation wells is primarily a result of seasonal differences in water use and pumping, rather than changes in aquifer response to seasonal recharge. The increases in water levels at the center of the cone of depression reflect changes in withdrawals from the Memphis aquifer, particularly at the well fields near the center of the cone. From 2000 to 2015, the average daily withdrawals for Shelby County decreased from about 188 to 142 Mgal/d (Dieter and others, 2017; USGS, 2017b). Water use in 2005 was 187 Mgal/d, which was similar to water use in 2000, but water use decreased to 173 Mgal/d in 2010 (USGS, 2017b). Water-level data for the long-term observation wells can be accessed at the Memphis area groundwater-level network web page (USGS, 2017c).

Water levels in well Fa:R-002, located outside and northeast of the cone of depression (fig. 5), have declined from about 38 ft below land surface in 1949 to a maximum low water level of about 44 ft below land surface during 2012. After an initial decline in about 1953, water levels were relatively stable between about 1955 and 2000, with an average water level of about 40.5 ft below land surface. Since 2000, the average water level has been about 41.5 ft below land surface. The relatively recent decline (since about 2010) in water levels likely is the result of increases in groundwater withdrawals for irrigation near this well rather than withdrawals in the Memphis area.

Well Sh:Q-001 is located between well Fa:R-002 and the center of the cone of depression. Water levels in well Sh:Q-001 declined about 35 ft between 1940 and 2015 (fig. 5). The rate at which water levels were declining began to slow down in about 2002, with little to no additional long-term declines since that time.

Water levels near the center of the cone of depression in well Sh:P-076 declined about 70 ft from 1929 to 1975 (fig. 1). Between 1975 and 1995, water levels in this well did not decline and subsequently began a recovery of about 30 ft such that the net decline over the period of record is about 40 ft. Because of the age of this well, there is some question about the connection of the well screen to the Memphis aquifer and whether the water level in the well may be somewhat higher than the water level in the aquifer because of leakage of groundwater from shallower zones through the well casing. However, water levels at another observation well, Sh:O-212, at the Mallory well field also have risen by 30 to 40 ft over the same timeframe (USGS, 2017c).

Water-level data for wells located north (Sh:O-001) and south (Sh:J-001) of the center of the cone of depression indicate that water levels stabilized in the areas near these wells and that the cone has not expanded to the north and south. Water levels in well Sh:O-001 have not declined substantially since 1990, and water levels in well Sh:J-001 have not declined since about 2000 (fig. 5). At both wells, it appears that water levels have recovered somewhat from their period-of-record lows.

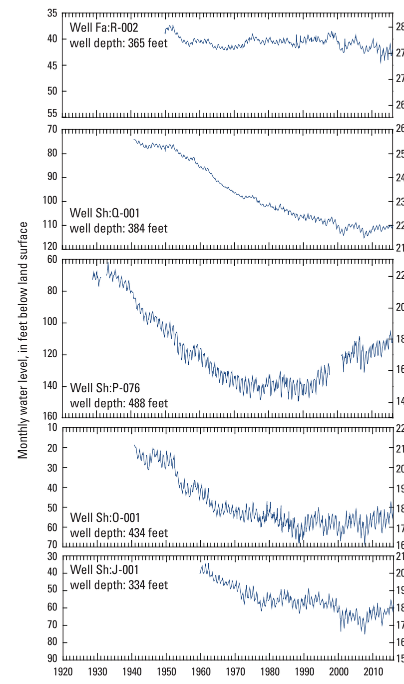

Figure 5. Historical water-level changes in selected Memphis aquifer wells located away from well fields.

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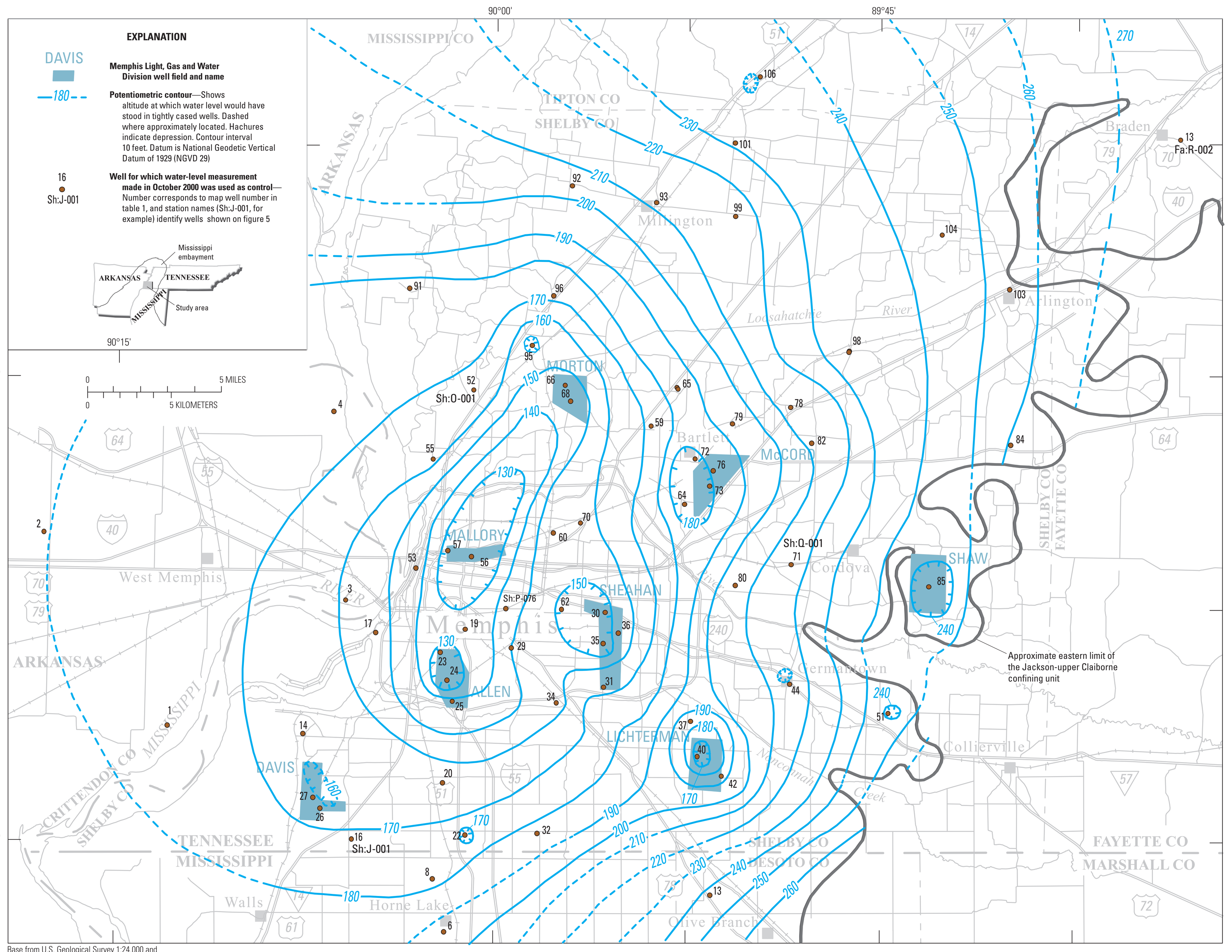
Table 1. Summary of groundwater-level measurements and groundwater-level altitudes in the Memphis aquifer, 2000–15.

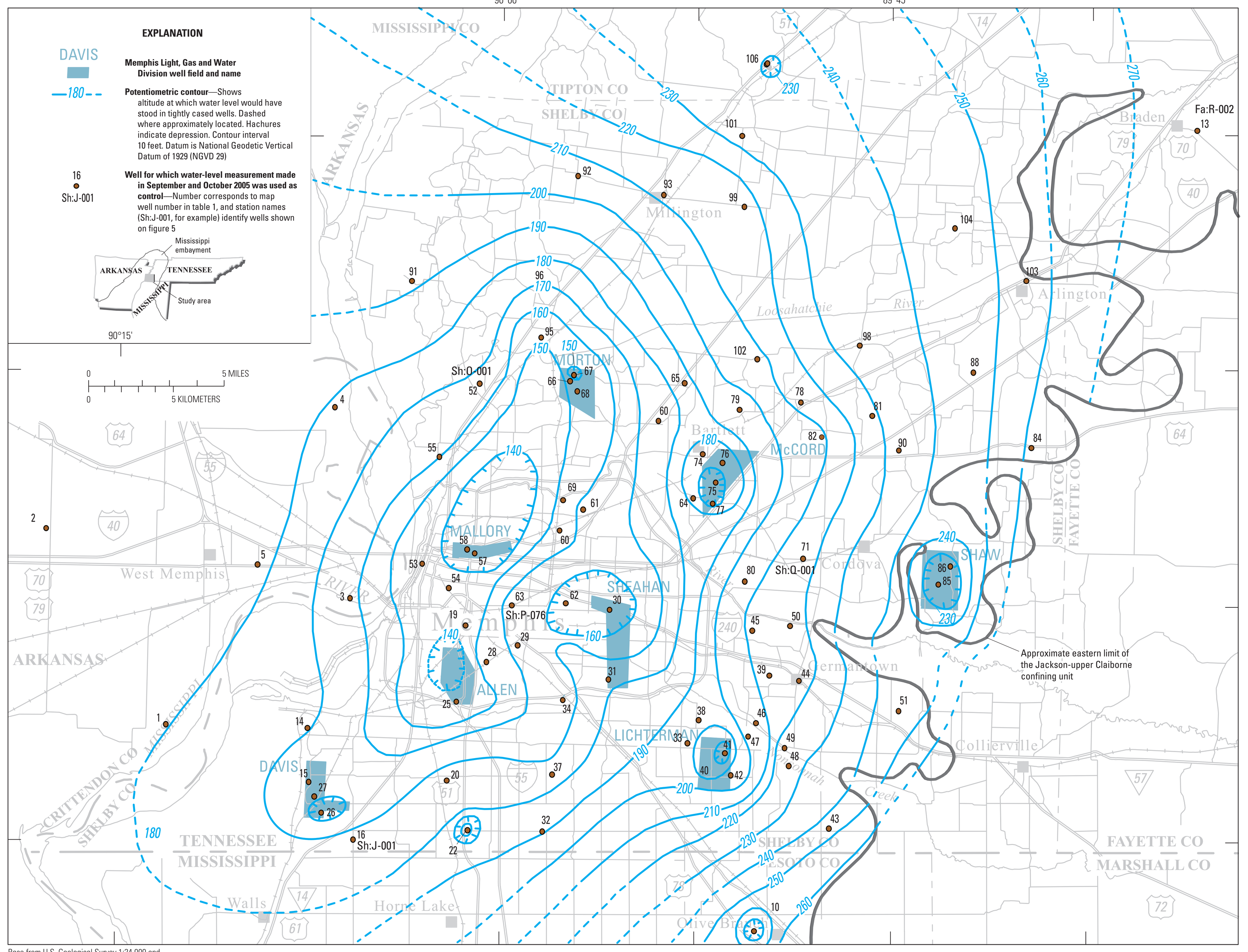
[NGVD 29, National Geodetic Vertical Datum of 1929; – , no measurement]

Map well number (see figs. 1–4)	Site name	Land-surface altitude, in feet above NGVD 29	Date	Depth below land surface, in feet	Water-level altitude, in feet above NGVD 29	Date	Depth below land surface, in feet	Water-level altitude, in feet above NGVD 29	Date	Depth below land surface, in feet	Water-level altitude, in feet above NGVD 29	Date	Depth below land surface, in feet	Water-level altitude, in feet above NGVD 29
1	05N08E11CCA2	211	10/18/00	33.36	177.64	10/21/05	30.98	180.02	10/06/10	28.16	182.84	10/29/15	28.26	182.74
2	06N07E01DAD2	209	10/18/00	28.9	180.1	10/21/05	27.36	181.64	10/14/10	26.68	182.32	10/29/15	27.26	181.74
3	06N09E23AAB1	222	10/18/00	63.85	158.15	10/31/05	60.73	161.27	10/21/10	57.23	164.77	10/29/15	51.6	170.4
4	07N09E14BAC1	216	10/18/00	39.17	176.83	10/21/05	37.42	178.58	10/14/10	33.41	182.59	10/29/15	32.66	183.34
5	Ar:N-001	215	–	–	–	10/21/05	33.19	181.81	10/15/10	30.5	184.5	10/22/15	30.85	184.15
6	B0009 DESOTO	300	11/09/00	104.85	195.15	–	–	–	10/13/10	103.81	196.19	11/03/15	98.34	201.66
7	B0063 DESOTO	288	–	–	–	–	–	–	10/13/10	93.04	194.96	11/03/15	87.73	200.27
8	B0068 DESOTO	285	11/03/00	107	178	–	–	–	–	–	–	–	–	–
9	D0026 DESOTO	400	–	–	–	–	–	–	10/14/10	139.05	260.95	11/03/15	150.67	249.33
10	D0046 Desoto	410	–	–	–	10/20/05	174.17	235.83	–	–	–	–	–	–
11	G0075 DESOTO	390	–	–	–	–	–	–	10/14/10	178.7	211.3	11/03/15	179.17	210.83
12	Ms:D-057	398	10/20/00	153.65	244.35	–	–	–	10/07/10	154.94	243.06	10/26/15	153.94	244.06
13	Fa:R-002	317.2	10/11/00	41.98	275.22	09/27/05	40.66	276.54	10/05/10	41.53	275.67	11/05/15	42.46	274.74
14	Sh:H-001	312	10/17/00	143.92	168.08	11/01/05	140.43	171.57	11/17/10	136.79	175.21	10/21/15	134.29	177.71
15	Sh:H-008	305	–	–	–	10/20/05	142	163	–	–	–	–	–	–
16	Sh:J-001	240.5	10/17/00	68.36	172.14	09/29/05	69.56	170.94	10/06/10	67.15	173.35	10/27/15	62.36	178.14
17	Sh:J-028	289	10/17/00	133.14	155.86	–	–	–	12/01/10	123.1	165.9	–	–	–
18	Sh:J-030	295	–	–	–	–	–	–	–	–	–	10/21/15	119.64	175.36
19	Sh:J-037	305	10/17/00	171.49	133.51	11/02/05	159.98	145.02	11/18/10	167.21	137.79	–	–	–
20	Sh:J-070	298	10/18/00	129.12	168.88	10/20/05	125.71	172.29	11/17/10	122.13	175.87	10/29/15	119.25	178.75
21	Sh:J-074	305	–	–	–	–	–	–	11/18/10	133.8	171.2	10/29/15	132.9	172.1
22	Sh:J-075	303	10/18/00	136.12	166.88	10/20/05	133.98	169.02	–	–	–	–	–	–
23	Sh:J-097	280	10/17/00	159.44	120.56	–	–	–	–	–	–	–	–	–
24	Sh:J-120	243	10/19/00	118.9	124.1	–	–	–	–	–	–	–	–	–
25	Sh:J-126	234.5	10/17/00	92.28	142.22	09/29/05	86.93	147.57	10/06/10	78.96	155.54	10/27/15	67.59	166.91
26	Sh:J-139	292	10/17/00	128.19	163.81	10/20/05	136.94	155.06	–	–	–	–	–	–
27	Sh:J-140	293	10/17/00	129.97	163.03	10/04/05	127.18	165.82	10/06/10	126.37	166.63	10/27/15	118.23	174.77
28	Sh:J-230	272	–	–	–	10/31/05	116.77	155.23	–	–	–	–	–	–
29	Sh:K-021	295	10/12/00	144.83	150.17	11/01/05	133.73	161.27	–	–	–	10/24/15	125.55	169.45
30	Sh:K-066	302.7	10/17/00	159.98	142.72	09/27/05	143.39	159.31	10/05/10	145.26	157.44	10/26/15	130.7	172
31	Sh:K-072	252	10/13/00	83.47	168.53	09/27/05	75.16	176.84	11/15/10	72.5	179.5	11/02/15	68.19	183.81
32	Sh:K-079	350	10/13/00	162.07	187.93	09/30/05	160.08	189.92	–	–	–	10/21/15	156.25	193.75
33	Sh:K-120 UR-12	293	–	–	–	10/13/05	98.28	194.72	–	–	–	–	–	–
34	Sh:K-122	238	10/13/00	81.2	156.8	10/13/05	74.3	163.7	11/18/10	69.81	168.19	–	–	–
35	Sh:K-138	280	10/19/00	133.91	146.09	–	–	–	–	–	–	–	–	–
36	Sh:K-140	297	10/12/00	139.65	157.35	–	–	–	–	–	–	–	–	–
37	Sh:K-165	272	–	–	–	11/02/05	100.32	171.68	–	–	–	–	–	–
38	Sh:L-013	301	10/16/00	115.3	185.7	10/19/05	107.25	193.75	11/17/10	105.07	195.93	10/28/15	105.77	195.23
39	Sh:L-018	322	–	–	–	10/05/05	110.17	211.83	–	–	–	–	–	–
40	Sh:L-024	344	10/13/00	176.3	167.7	–	–	–	11/17/10	164.6	179.4	10/29/15	158	186
41	Sh:L-026	353	–	–	–	10/19/05	180.5	172.5	–	–	–	–	–	–
42	Sh:L-039	345	10/16/00	157.95	187.05	09/29/05	150.65	194.35	10/05/10	153.07	191.93	10/26/15	148.91	196.09
43	Sh:L-052	390	–	–	–	10/14/05	143.82	246.18	–	–	–	–	–	–
44	Sh:L-089	375	10/17/00	163.26	211.74	10/04/05	159.03	215.97	10/07/10	162.88	212.12	11/05/15	161.04	213.96
45	Sh:L-105 UR-20	268	–	–	–	10/05/05	55.6	212.4	–	–	–	–	–	–
46	Sh:L-106 UR-21	283	–	–	–	10/18/05	77.06	205.94	–	–	–	–	–	–
47	Sh:L-107 UR-22	286	–	–	–	10/13/05	81.85	204.15	–	–	–	–	–	–
48	Sh:L-109 UR-24	295	–	–	–	10/14/05	67.83	227.17	–	–	–	11/03/15	67.83	227.17
49	Sh:L-111 UR-25M	291	–	–	–	10/13/05	62.92	228.08	–	–	–	–	–	–
50	Sh:L-115	257	–	–	–	10/31/05	44.77	212.23	–	–	–	–	–	–
51	Sh:M-040	348	10/17/00	108.16	239.84	10/04/05	104.05	243.95	10/07/10	113.29	234.71	11/05/15	101.6	246.4
52	Sh:O-001	228.7	10/13/00	63.95	164.75	09/28/05	61.22	167.48	10/05/10	59.57	169.13	10/27/15	52.78	175.92
53	Sh:O-029	265	10/17/00	123.47	141.53	10/05/05	118.92	146.08	10/20/10	117.76	147.24	10/27/15	107.96	157.04
54	Sh:O-105	275	–	–	–	10/06/05	130.35	144.65	–	–	–	–	–	–
55	Sh:O-115	277	10/16/00	115.59	161.41	09/30/05	116.67	160.33	10/20/10	114.5	162.5	11/04/15	107.75	169.25
56	Sh:O-204	257	10/19/00	132.47	124.53	–	–	–	–	–	–	–	–	–
57	Sh:O-212	251	10/16/00	121.22	129.78	09/29/05	113.82	137.18	10/07/10	112.01	138.99	10/26/15	99.09	151.91
58	Sh:O-231	251	–	–	–	10/20/05	114.1	136.9	–	–	–	–	–	–
59	Sh:P-001	299.8	10/11/00	128.54	171.26	09/29/05	125.12	174.68	10/05/10	125.1	174.7	10/26/15	118.27	181.53
60	Sh:P-012	262	10/12/00	110.82	151.18	10/12/05	110.92	151.08	–	–	–	10/19/15	97.72	164.28
61	Sh:P-037	252	–	–	–	10/19/05	85.46	166.54	–	–	–	10/23/15	84.68	167.32
62	Sh:P-061	280	10/12/00	131.69	148.31	10/06/05	121.71	158.29	11/18/10	115.95	164.05	11/04/15	109.34	170.66
63	Sh:P-076	286.7	–	–	–	09/29/05	118.89	167.81	10/06/10	117.8	168.9	10/26/15	109	177.7
64	Sh:P-085	293	10/11/00	120.05	172.95	09/28/05	114.28	178.72	10/05/10	110.24	182.76	10/26/15	109.08	183.92
65	Sh:P-096	312	10/11/00	127.48	184.52	10/12/05	122.7	189.3	10/21/10	124.45	187.55	11/04/15	117.96	194.04
66	Sh:P-113	301.5	10/19/00	153.24	148.26	09/30/05	150.44	151.06	10/05/10	151.85	149.62	10/27/15	139.67	161.8
67	Sh:P-128	290	–	–	–	10/12/05	143.74	146.26	–	–	–	–	–	–
68	Sh:P-131	247	10/12/00	98.19	148.81	10/20/05	91.29	155.71	–	–	–	–	–	–
69	Sh:P-143	229	–	–	–	10/12/05	78.68	150.32	11/18/10	72.83	156.17	10/20/15	67.87	161.13
70	Sh:P-232	252	10/31/00	95.31	156.69	–	–	–	–	–	–	–	–	–
71	Sh:Q-001	330.4	10/11/00	113.66	216.74	10/04/05	111.76	218.64	10/05/10	112.74	217.66	10/26/15	111.56	218.84
72	Sh:Q-052	295	10/11/00	117.6	177.4	–	–	–	–	–	–	–	–	–
73	Sh:Q-059	308	10/11/00	136.6	171.4	–	–	–	10/05/10	128.62	179.38	10/26/15	122.08	185.92
74	Sh:Q-060	285	–	–	–	10/18/05	106.06	178.94	11/09/10	104.67	180.33	10/28/15	99.44	185.56
75	Sh:Q-063	309	–	–	–	10/19/05	141.54	167.46	–	–	–	–	–	–
76	Sh:Q-069	280	10/11/00	98.45	181.55	10/20/05	108.75	171.25	–	–	–	–	–	–
77	Sh:Q-071	302	–	–	–	10/19/05	132.8	169.2	–	–	–	–	–	–
78	Sh:Q-075	305	10/11/00	88.62	216.38	10/11/05	87.12	217.88	10/22/10	87.44	217.56	10/28/15	87.12	217.88
79	Sh:Q-081	317	10/11/00	125.57	191.43	09/28/05	122.58	194.42	11/09/10	121.59	195.41	–	–	–
80	Sh:Q-126	250	10/17/00	45.33	204.67	10/22/10	41.03	208.97	10/22/10	41.11	208.89	10/28/15	40.97	209.03
81	Sh:Q-188	393	–	–	–	10/12/05	165.51	227.49	–	–	–	–	–	–
82	Sh:Q-190	327	10/11/00	109.65	217.35	–	–	–	–	–	–	–	–	–
83	Sh:Q-194	307	–	–	–	–	–	–	–	–	–	10/28/15	109.24	197.76
84	Sh:R-015	342	10/10/00	80.34	261.66	–	–	–	–	–	–	–	–	–
85	Sh:R-031	325	10/10/00	93.26	231.74	09/28/05	98.35	223.65	10/05/10	97.58	224.42	10/26/15	91.08	230.92
86	Sh:R-041	370	–	–	–	10/31/05	145.78	224.22	–	–	–	–	–	–
87	Sh:R-048	332	–	–	–	09/28/05	66.72	265.28	–	–	–	11/03/15	68.4	263.6
88	Sh:R-051	272	–	–	–	09/27/05	25.3	246.7	–	–	–	–	–	–
89	Sh:R-052	298	–	–	–	–	–	–	–	–	–	11/05/15	57.02	240.98
90	Sh:R-054	383	–	–	–	11/04/05	149.77	233.23	–	–	–	11/03/15	150.75	232.25
91	Sh:T-017	330	10/16/00	154.47	175.53	09/27/05	138.13	191.87	10/20/10	137.86	192.14	10/22/15	137.27	192.73
92	Sh:U-002	268.8	10/12/00	64.76	204.04	09/27/05	61.18	207.62	10/06/10	61.25	207.51	11/04/15	59.25	209.51
93	Sh:U-007	270	10/12/00	56.68	213.32	09/28/05	53.13	216.87	10/20/10	54.88	215.12	–	–	–
94	Sh:U-008	265	–	–	–	–	–	–	–	–	–	10/22/15	53.75	211.25
95	Sh:U-015	240	10/16/00	98.77	141.23	09/29/05	88.84	151.16	–	–	–	–	–	–
96	Sh:U-022	300	10/12/00	126.79	173.21	–	–	–	–	–	–	–	–	–
97	Sh:U-029	242	–	–	–	–	–	–	10/21/10	90.36	151.64	10/20/15	76.27	165.73
98	Sh:V-007	282	10/11/00	46.83	235.17	09/27/05	45.48	236.52	10/21/10	46.63	235.37	11/09/15	44.78	237.22
99	Sh:V-009	273	10/12/00	60.74	212.26	09/28/05	57.4	215.6	10/20/10	58.13	214.84	11/02/15	56.34	216.63
100	Sh:V-024	375	–	–	–	–	–	–	–	–	–	10/20/15	140.68	234.32
101	Sh:V-025	375	10/12/00	143.35	231.65	09/28/05	139.72	235.28	10/20/10	140.65	234.35	–	–	–
102	Sh:V-268	291	–	–	–	10/12/05	83.63	207.37	–	–	–	–	–	–
103	Sh:W-003	279	10/10/00	22.47	256.53	09/27/05	21.55	257.45	10/05/10	22.48	256.53	11/05/15	22.61	256.4
104	Sh:W-016	362	10/10/00	116.38	245.62	09/27/05	115.26	246.74	10/21/10	116.52	245.48	–	–	–
105	Sh:W-030	300	–	–	–	–	–	–	–	–	–	11/05/15	43.06	256.94
106	Tp:E-012	337	10/12/00	106.13	230.87	09/29/05	107.27	229.73	10/20/10	109.14	227.86	10/28/15	107.78	229.22



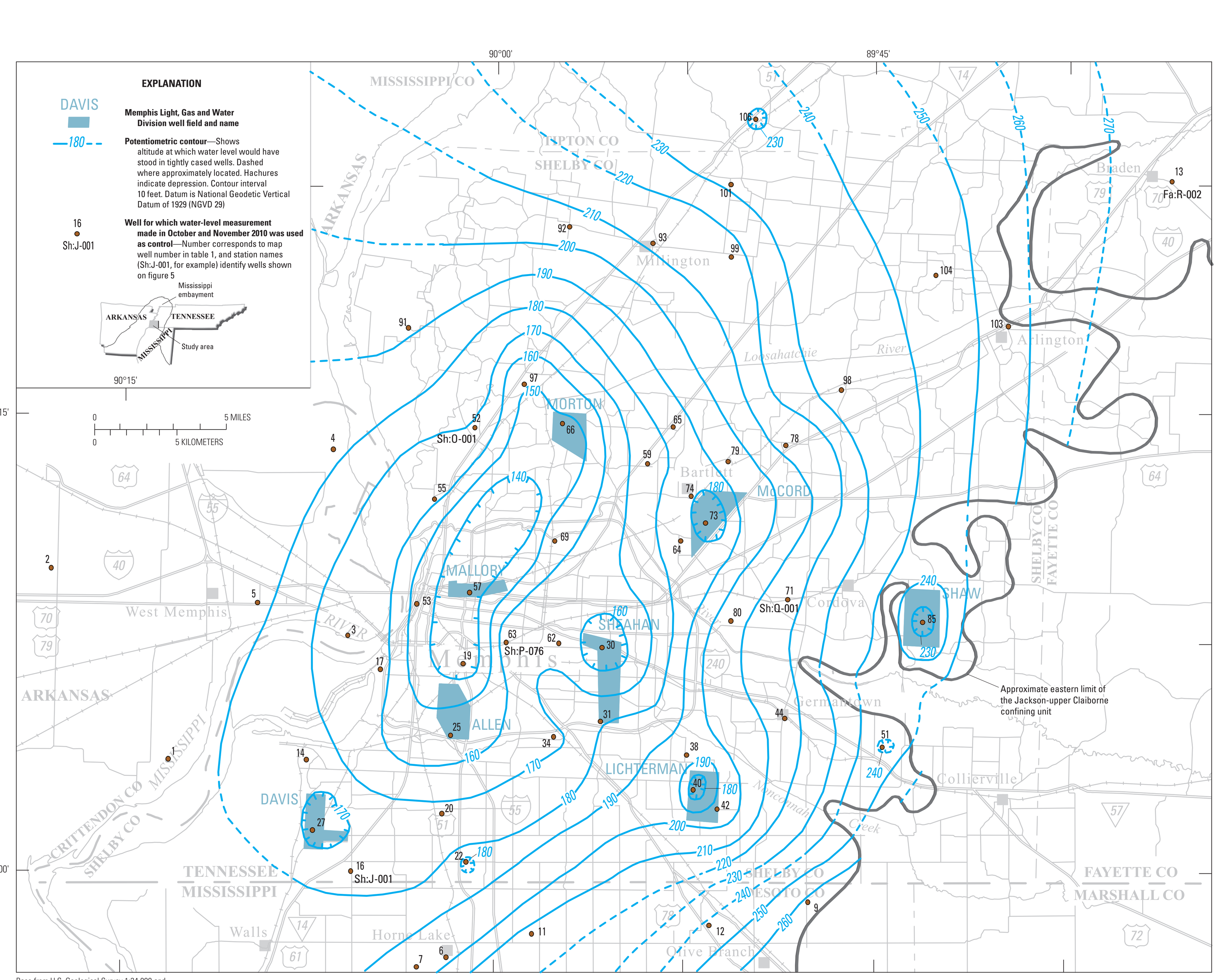
Base from U.S. Geological Survey 1:24,000 and Mississippi River Commission 1:62,500 quadrangles North American Datum of 1983

Figure 1. Altitude of the potentiometric surface of the Memphis aquifer in the Memphis area, Tennessee, October 2000.



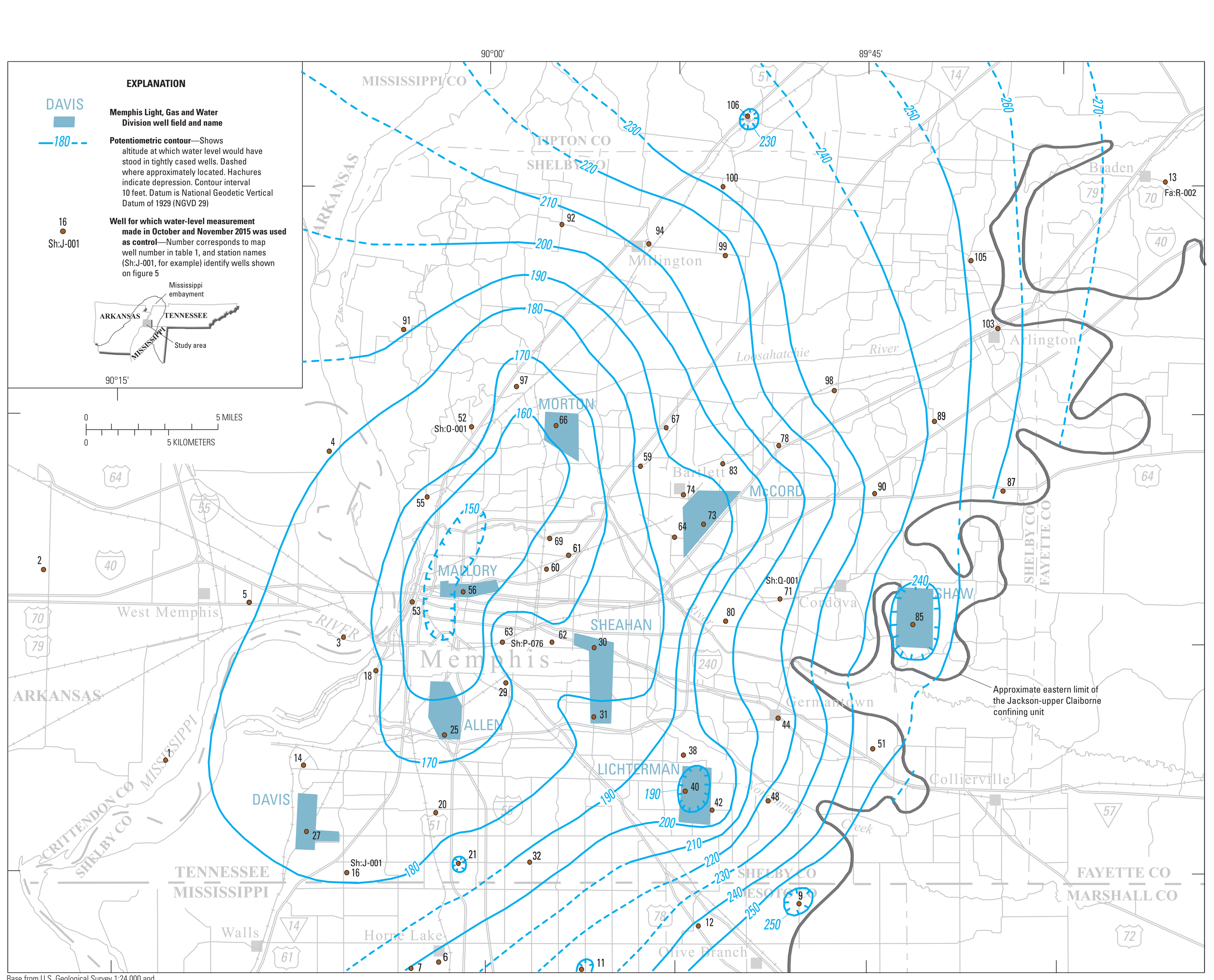
Base from U.S. Geological Survey 1:24,000 and Mississippi River Commission 1:62,500 quadrangles North American Datum of 1983

Figure 2. Altitude of the potentiometric surface of the Memphis aquifer in the Memphis area, Tennessee, September and October 2005.



Base from U.S. Geological Survey 1:24,000 and Mississippi River Commission 1:62,500 quadrangles North American Datum of 1983

Figure 3. Altitude of the potentiometric surface of the Memphis aquifer in the Memphis area, Tennessee, October and November 2010.



Base from U.S. Geological Survey 1:24,000 and Mississippi River Commission 1:62,500 quadrangles North American Datum of 1983

Figure 4. Altitude of the potentiometric surface of the Memphis aquifer in the Memphis area, Tennessee, October and November 2015.

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